CSC 261/461
Database Systems

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Nonadditive (Lossless) Join

Algorithm

Input: A universal relation R, a decomposition $D = R_1, R_2, \ldots, R_m$ of R, and a set F of FD.

1. Create an initial matrix S with one row i for each R_i, and one column j for each attribute A_j in R.
2. Set $S(i, j) = b_{ij}$ for all matrix entries. (distinct symbols)
3. For each row i representing relation schema Ri
   {for each column j representing attribute A_j
   {if (relation R_i includes attribute A_j)
   then set $S(i, j) = a_j$ }} (distinct symbols).

Nonadditive (Lossless) Join

Algorithm

4. Repeat until no changes to S
   {for each FD $X \rightarrow Y$ in F
   {for all rows in S that have the same symbols in
   the columns corresponding to attributes in X
   {make the symbols in each column that
   correspond to an attribute in Y be the
   same in all these rows as follows:
   If any of the rows has an *a* symbol for
   the column, set the other rows to that same
   a symbol in the column.
   If no *a* symbol exists for the
   attribute in any of the rows,
   choose one of the *b* symbols that appears
   in one of the rows for the attribute and set
   the other rows to that same b symbol in the column } }
   }
5. If a row is made up entirely of *a* symbols, then the decomposition has the nonadditive join property; otherwise, it does not.

Nonadditive Join Algorithm

Example

(a) $R = \{\text{Ssn, Ename, Pnumber, Pname, Plocation, Hours}\}$ $\quad D = \{R_1, R_2\}$

$R_1 = \text{EMP\_LOCS} = \{\text{Ename, Plocation}\}$

$R_2 = \text{EMP\_PROJ1} = \{\text{Ssn, Pnumber, Hours, Pname, Plocation}\}$

$F = \{\text{Ssn} \rightarrow \text{Ename; Pnumber} \rightarrow \{\text{Pname, Plocation}\}; \{\text{Ssn, Pnumber}\} \rightarrow \text{Hours}\}$

	Ssn	Ename	Pnumber	Pname	Plocation	Hours
R_1	b_{11}	a_2	b_{13}	b_{14}	a_5	b_{16}
R_2	a_1	b_{22}	a_3	a_4	a_5	a_6

(No changes to matrix after applying functional dependencies)

NJB (Nonadditive Join Test for Binary Decompositions). A decomposition $D = \{R_1, R_2\}$ of R has the lossless (nonadditive) join property with respect to a set of functional dependencies F on R *if and only if* either

- The FD $((R_1 \cap R_2) \rightarrow (R_1 - R_2))$ is in F^{+15}, or
- The FD $((R_1 \cap R_2) \rightarrow (R_2 - R_1))$ is in F^{+}

Relational Synthesis into 3NF with Dependency Preservation and Nonadditive Join Property

Algorithm 3NF+

The algorithm achieves the following:

- Preserves dependencies
- Has the nonadditive join property
- Is such that each resulting relation schema in the decomposition is in 3NF

Relational Synthesis into 3NF with Dependency Preservation and Nonadditive Join Property

Algorithm 3NF+

- **Input**: A universal relation R and a set of functional dependencies F on the attributes of R.
  1. Find a minimal cover G for F.
  2. For each LHS X of an FD in G, create a relation in D with attributes $\{X \cup \{A_1\} \cup \{A_2\} \ldots \cup \{A_k\}\}$, where $X \rightarrow A_1, X \rightarrow A_2, \ldots, X \rightarrow A_k$ are the only FDs in G with X as LHS (X is the key of this relation).
  3. If none of the relation schemas in D contains a key of R, then include it in another relation.
  4. Eliminate redundant relations from the resulting set of relations in the relational database schema.

Relational Synthesis into 3NF with Dependency Preservation and Nonadditive Join Property

Algorithm 3NF+ (example)

Consider the following universal relation:

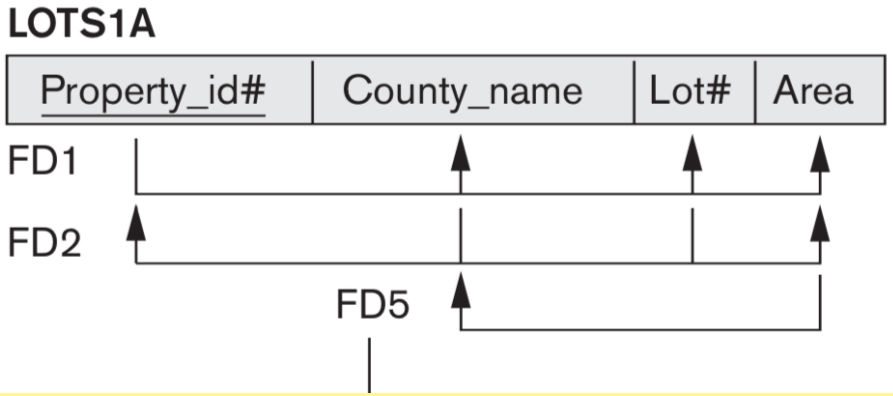
`U(Emp_ssn, Pno, Esal, Ephone, Dno, Pname, Plocation)`

Assume the following FDs:

- FD1: $Emp\_ssn \rightarrow \{Esal, Ephone, Dno\}$
- FD2: $Pno \rightarrow \{Pname, Plocation\}$
- FD3: $Emp\_ssn, Pno \rightarrow \{Esal, Ephone, Dno, Pname, Plocation\}$

Relational Synthesis into 3NF with Dependency Preservation and Nonadditive Join Property

Algorithm 3NF+ (example)



Assume universal relation:

$$U(Property\_id, County\_name, Lot\#, Area)$$

Assume FDs: $F = \{P \rightarrow LCA, LC \rightarrow AP, A \rightarrow C\}$

Relational Decomposition into BCNF with Nonadditive Join Property

Algorithm BCNF

- **Input**: A universal relation R and a set of FDs F on the attributes of R.
  1. Set D = {R}
  2. While there is a relation schema Q in D that is not in BCNF do {
     choose a relation schema Q in D that is not in BCNF;
     find an FD $X \rightarrow Y$ in Q that violates BCNF;
     replace Q in D by two relations $(Q - Y)$ and $(X \cup Y)$;
     };

Relational Decomposition into BCNF with Nonadditive Join Property

Algorithm BCNF

TEACH

Student	Course	Instructor
Narayan	Database	Mark
Smith	Database	Navathe
Smith	Operating Systems	Ammar
Smith	Theory	Schulman
Wallace	Database	Mark
Wallace	Operating Systems	Ahamad
Wong	Database	Omiecinski
Zelaya	Database	Navathe
Narayan	Operating Systems	Ammar

Assume:

- FD1: $\{Student, Course\} \rightarrow Instructor$
- FD2: $Instructor \rightarrow Course$

Questions?